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(54) [Title of the Invention] LASER OPTICAL DEVICE

(57) [Abstract]

[Object] To obtain a small device which takes out only a desired modulated beam by increasing a separation angle between the desired modulated beam and unnecessary diffraction beams from a plurality of diffraction beams which are obtained when an

acousto-optic modulator AOM is used.

[Constitution] A beam which is emitted from a laser light source 1 and enters an AOM 2 is modulated by the AOM 2 and is emitted to be divided into a plurality of diffraction beams. An optical axis of an optical element 32 having positive power is arranged to conform to a beam axis of a desired modulated beam among them. Beam axes of each of diffraction beams which are emitted from the optical element 32 once converge at the rear of a focal point of the optical element 32, and travel as divergent beams. Only the desired modulated beam can be obtained by providing a light shielding member 4 at a position sufficiently distant from the optical element 32.

[Scope of Claims]

[Claim 1] A laser optical device comprising an optical intensity modulation means using an acousto-optic modulator, characterized in that:

an optical axis of an optical element having negative power is disposed at the same axis as a beam axis of a desired modulated beam emitted from the acousto-optic modulator at the rear of the acousto-optic modulator,

separation angles between a plurality of diffraction beams having different output angles from each other emitted from the acousto-optic modulator are extended; and

a light shielding member having an opening which passes only the desired modulated beam and dose not pass the other unnecessary diffraction beams is disposed so that the center of the opening agrees with the optical axis to block the unnecessary diffraction beams.

[Claim 2] A laser optical device comprising an optical intensity modulation means using an acousto-optic modulator, characterized in that:

an optical axis of an optical element having positive power is disposed at the same axis as a beam axis of a desired modulated beam emitted from the acousto-optic modulator at the rear of the acousto-optic modulator,

beam axes of a plurality of unnecessary diffraction beams having different output angles emitted from the acousto-optic modulator are once crossed with the optical axis of the optical element at a convergent point at the rear of a focal point of the

optical element and after that the beam axes are diverged to increase separation angles; and

a light shielding member having an opening which passes only the desired modulated beam and dose not pass the other unnecessary diffraction beams is disposed at a position distant from the convergent point by the distance equal to or more than the distance from the optical element to the convergent point so that the center of the opening agrees with the optical axis to block the unnecessary diffraction beams.

[Claim 3] A laser optical device comprising an optical intensity modulation means using an acousto-optic modulator, characterized in that:

an optical axis of an afocal optical system composed of two groups of lenses having positive power is disposed at the same axis as a beam axis of a desired modulated beam emitted from the acousto-optic modulator at the rear of the acousto-optic modulator,

by refracting action of the former group of the afocal optical system, beam axes of a plurality of unnecessary diffraction beams having different output angles emitted from the acousto-optic modulator are once converged at the rear of a focal point of the optical element and after that the beam axes are diverged to increase separation angles; and

a light shielding member having an opening which passes only the desired modulated beam and dose not pass the other unnecessary diffraction beams is disposed at a position immediately in front of or immediately behind the latter group of the afocal optical system so that the center of the opening agrees with the optical axis to block the unnecessary diffraction beams.

[Claim 4] The laser optical device according to Claim 3, characterized in that:

an afocal optical system is a beam expander in which focal length of the latter group is longer than that of the former group.

[Claim 5] A laser optical device comprising a beam synthesizing means which is composed of a plurality of deflectors for modulating a plurality of laser beams having different wavelengths using corresponding acousto-optic modulators respectively and for synthesizing beam axes of each of desired modulated beams among a plurality of

diffraction beams to be obtained on the same axis, characterized in that:

a synthesized beam including different wavelengths, which is synthesized by the beam synthesizing means, and which is provided backward, and optical axis of which is conformed to the beam axis, enters an afocal optical system composed of an achromatic lens; and

a light shielding member having an opening which passes only the synthesized beam and dose not pass the other unnecessary diffraction beams is disposed at a position immediately in front of or immediately behind the latter group of the afocal optical system so that the center of the opening agrees with the optical axis to take out only the desired modulated beams as a parallel beam.

[Claim 6] The laser optical device according to Claim 5, characterized in that:

by varying carrier frequency of ultrasonic wave which is inputted into the acousto-optic modulators respectively corresponding to the wavelengths of incident laser beams, separation angles between the plurality of diffraction beams are made almost equal to each other,

beam axes of the desired modulated beams are synthesized on the same axis by the beam synthesizing means; and

an optical paths of the unnecessary diffraction beams are almost conformed.

[Claim 7] The laser optical device according to Claim 5 or 6, characterized in that:

an achromatic collective lens is disposed at the rear of the afocal optical system.

[Claim 8] The laser optical device according to Claim 5, 6 or 7, characterized in that:

the beam having a long wavelength has larger diameter than the beam having a short wavelength among the beams entering the afocal optical system.

[Claim 9] A beam scanner comprising the laser optical device according to any one of Claims 1 to 8, characterized in that:

one or two of beam scanning means for scanning the desired modulated beams is included posterior to the all optical systems.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention] The present invention relates to a laser device using an acousto-optic device (hereinafter referred to as an AOM) as a beam intensity modulation means which can be used in a laser marker, a laser trimmer, a laser display, or the like, or relates to a beam scanner in which a beam scanning mechanism is added to the laser device. More particularly, the present invention relates to a technique for clearly separating a desired modulated beam diffracted by the AOM from the other unnecessary diffraction beams and taking out only the desired modulated beam.

[0002]

[Related Art] It is known that a laser device having various functions can be formed by modulating a laser beam by an AOM. The AOM can modulate intensity of an incident beam and is used in a wide variety of laser devices such as a laser marker, a laser trimmer, and a laser display. As a laser intensity modulation method, there is a direct modulation method, which is often employed in a low-power semiconductor laser. However, in the direct modulation method, duty ratio decreases when laser output rises. On the other hand, the AOM is an effective modulation means in a laser device which uses a high-power watt-level laser because the duty ratio can be maintained even when laser beam power is high.

[0003] As diffraction beams emitted from the AOM, there are two lights, zero order light and first order light. However, at the same time, diffracted lights of minus first order light and second order light can be emitted depending on the incident condition of a beam, or the like. Among them, only the first order diffraction light is usually used as modulated light. This is referred to as a desired modulated beam. The other beams are referred to unnecessary diffraction beams because they are not needed. It is necessary to block the unnecessary diffraction beams. However, diffraction separation angles between the diffraction beams emitted from the AOM are very small, a few milliradians. Therefore, it is difficult to block only the unnecessary diffraction beams in the neighborhood of the AOM. When the beams other than the desired modulated beam are blocked by a light shielding plate with an opening, a beam diameter and an opening diameter become almost equal. Then, the beam is diffracted by the edge of the opening. In addition, when the opening position is misaligned, the amount of

transmitted light is reduced and light use efficiency is decreased.

[0004] As a technique for blocking unnecessary diffraction beams and taking out a desired modulated beam, one that is disclosed in Japanese Patent Laid-Open No. H9-5689 is known. In this technique, a plurality of diffraction beams with small separation angles which are emitted from an AOM are guided to a beam expander which is composed of two groups of convex lenses, and a light shielding plate with a pinhole is provided at a focal plane of the former group to pass only the desired modulated beam.

[0005]

[Problems to be Solved by the Invention] At a point sufficiently distant from an AOM, unnecessary diffraction beams can be easily blocked since the distance between a plurality of diffraction beams increases; however, a device becomes large in size because of a requirement of a long optical path length. As a method for avoiding this, it is possible to reduce the size of a device by bending an optical path with a mirror; however, the device structure becomes complex and also adjustment becomes complicated. As another method of the related art which increases the distance between the plurality of diffraction beams, there is a method for providing a wedge substrate in an output end side of an AOM as shown in FIG. 10. A plurality of diffraction lights 1 and 2 which enters from the surface of a wedge substrate 3 transmits through a given substrate thickness and reflects off the back surface of the wedge substrate 3. Then, the plurality of diffraction lights 1 and 2 transmits through the substrate again and passes out from the surface of the wedge substrate 3. The above-described process can separate the plurality of adjacent diffraction lights 1 and 2 to some extent, and after that, block the unnecessary diffraction beams by using a light shielding member 4 having an opening 4a. In this method, however, beam astigmatism occurs and focusing properties degrade. In addition, since it is a system in which the optical path of the beam is bent, adjustment of the arrangement of the system is complicated when beams of three primary colors are synthesized in a subsequent stage of the system. Furthermore, since it is necessary to provide the system for each of optical paths of three primary colors, the arrangement of the system is more

complicated. With respect to an optical system described in the Japanese Patent Laid-Open No. H9-5689, even the plurality of beams which have small separation angle and partially overlap can be clearly separated by providing the light shielding plate with the pinhole which can transmit only the desired beam. However, since focusing points of each of the beams are considerably close, the tolerance which is given to the pinhole structure is not so large. Ideally, it is preferable that the opening is larger than the modulated beam diameter, thereby the unnecessary diffraction beams can be blocked, and long optical distance is not required.

[0006] In a laser device, a modulated beam is preferably propagated in a parallel state or a nearly parallel state. When the beam diverges, it is necessary to make a rear optical system larger, and therefore, cost is increased. From a principle of Gaussian propagation property of a laser beam, it is known that parallelism of a propagating beam improves when a beam diameter is large. However, in applications such as a laser marker, a laser trimmer, or a laser scan display, once the beam diameter is extended, depth of focus becomes shallow in converging finally; therefore, accuracy of the position of a surface to be processed or a screen becomes severe. Based upon the foregoing, it is rare to adopt an optical system which extends a beam diameter and improves the parallelism of a propagating beam. The point is that a beam is desirably propagated with a beam diameter kept as close as possible to a diameter of a beam which is emitted from a laser.

[0007] In a device in which each of lasers having different wavelengths is used to be modulated, there is a similar problem in AOM corresponding to each of the laser beams having different wavelengths. When each of the beams having different wavelengths passes through the AOM, the number of diffraction beams increases, and a method for efficiently blocking unnecessary diffraction beams among the diffraction beams simultaneously is desired. Desired modulated beams selected by the light shielding means have different wavelengths, and a device which condenses or scans these beams can be considered. In this case, a device structure which can conform light condensing positions or spot sizes of beams having different wavelengths is desired.

[0008] On the basis of these problems, it is a principal object of the present invention

to block unnecessary diffraction beams emitted from an AOM within a short optical path. In addition, it is a principal object to allow control of the parallelism of a desired modulated beam. Further, other objects are described below. Separating effect of diffraction light is raised, and processing precision of a component or accuracy of adjustment of installation is reduced. In a laser device in which lasers having different wavelengths are used simultaneously, all the unnecessary diffraction beams are simultaneously blocked, and the desired modulated beams are converted to a parallel beam. The modulated beams having different wavelengths are condensed at the same focal point. The beams having different wavelengths which are modulated by the AOM are scanned and condensed at the same spot and the spot sizes are the same. Furthermore, it is an object to provide a beam scanning device with the use of the laser optical devices.

[0009]

[Means for Solving the Problem] In order to solve the problems, in the invention according to Claim 1 of the application, a laser device having an optical intensity modulation means using an acousto-optic modulator (hereinafter referred to as an AOM) is characterized in that an optical axis of an optical element having negative power is disposed at the same axis as a beam axis of a desired modulated beam emitted from the AOM at the rear of the AOM, separation angles between a plurality of diffraction beams having different output angles from each other emitted from the AOM are extended, and a light shielding member having an opening which passes only the desired modulated beam and dose not pass the other unnecessary diffraction beams is disposed so that the center of the opening agrees with the optical axis to block the unnecessary diffraction beams.

[0010] In the invention according to Claim 2, a laser device having an optical intensity modulation means using an AOM is characterized in that an optical axis of an optical element having positive power is disposed at the same axis as a beam axis of a desired modulated beam emitted from the AOM at the rear of the AOM, beam axes of a plurality of unnecessary diffraction beams having different output angles emitted from the AOM are once crossed with the optical axis of the optical element at a convergent

point at the rear of a focal point of the optical element and after that the beam axes are diverged to increase separation angles, and a light shielding member having an opening which passes only the desired modulated beam and dose not pass the other unnecessary diffraction beams is disposed at a position distant from the convergent point by the distance equal to or more than the distance from the optical element to the convergent point so that the center of the opening agrees with the optical axis to block the unnecessary diffraction beams.

[0011] In the invention according to Claim 3, a laser device having an optical intensity modulation means using an AOM is characterized in that an optical axis of an afocal optical system composed of two groups of lenses having positive power is disposed at the same axis as a beam axis of a desired modulated beam emitted from the AOM at the rear of the AOM, by refracting action of the former group of the afocal optical system, beam axes of a plurality of unnecessary diffraction beams having different output angles emitted from the AOM are once converged at the rear of a focal point of the optical element and after that the beam axes are diverged to increase separation angles, and a light shielding member having an opening which passes only the desired modulated beam and dose not pass the other unnecessary diffraction beams is disposed at a position immediately in front of or immediately behind the latter group of the afocal optical system so that the center of the opening agrees with the optical axis to block the unnecessary diffraction beams.

[0012] The invention according to Claim 4 is characterized in that, in the laser optical device according to Claim 3, the afocal optical system is a beam expander in which focal length of the latter group is longer than that of the former group.

The invention according to Claim 5 is characterized in that, the laser optical device includes a beam synthesizing means which is composed of a plurality of deflectors for modulating a plurality of laser beams having different wavelengths using corresponding AOMs respectively and for synthesizing beam axes of each of desired modulated beams among a plurality of diffraction beams to be obtained on the same axis; a synthesized beam including different wavelengths, which is synthesized by the beam synthesizing means, and which is provided backward, and optical axis of which is

conformed to the beam axis, enters an afocal optical system composed of an achromatic lens; and a light shielding member having an opening which passes only the synthesized beam and dose not pass the other unnecessary diffraction beams is disposed at a position immediately in front of or immediately behind the latter group of the afocal optical system so that the center of the opening agrees with the optical axis to take out only the desired modulated beams as a parallel beam.

[0013] The invention according to Claim 6 is characterized in that, in the laser optical device according to Claim 5, by varying carrier frequency of ultrasonic wave which is inputted into the AOMs respectively corresponding to the wavelengths of incident laser beams, separation angles between the plurality of diffraction beams are made almost equal to each other, beam axes of the desired modulated beams are synthesized on the same axis by the beam synthesizing means, and the optical paths of the unnecessary diffraction beams are almost conformed. The invention according to Claim 7 is characterized in that, in the laser optical device according to Claim 5 or 6, an achromatic collective lens is disposed at the rear of the afocal optical system.

[0014] The invention according to Claim 8 is characterized in that, in the laser optical device according to Claim 6 or 7, the beam having a long wavelength has larger diameter than the beam having a short wavelength among the beams entering the afocal optical system. The invention according to Claim 9 is characterized in that, a beam scanner including the laser optical device according to any one of Claims 1 to 8 has one or two of beam scanning means for scanning the desired modulated beams posterior to the all optical systems.

[0015]

[Operation] According to the invention of Claim 1, the separation angles of the plurality of diffraction beams are increased by the optical element having negative power, and only the desired beams are taken out using the light shielding plate. According to the invention of Claim 2, the separation angles of the plurality of diffraction beams are increased by the optical element having positive power, and only the desired beams are taken out using the light shielding plate. According to the invention of Claim 3, the separation angles of the plurality of diffraction beams are

increased by the optical element having positive power, and the desired modulated beams transmitted through the opening of the light shielding plate hold parallelism of the beams after emitting from the afocal optical system.

[0016] According to the invention of Claim 4, the distance between the beam axes of the desired modulated beams and the beam axes of the unnecessary diffraction beams at the position of the light shielding member further increases. According to the invention of Claim 5, differences of optical paths depending on differences of wavelengths do not occur by conforming the beam axes of the plurality of desired modulated beams having different wavelengths. According to the invention of Claim 6, in the unnecessary diffraction beams, differences of optical paths depending on differences of wavelengths do not occur.

[0017] According to the invention of Claim 7, when it is applied to a beam scanner or the like, the desired modulated beams are focused on a predetermined image plane position. According to the invention of Claim 8, when it is applied to the beam scanner, the desired modulated beams having different wavelengths are focused on the predetermined image plane position with the same spot size. According to the invention of Claim 9, the beam scanner using each of the laser optical devices can be provided.

[0018]

[Embodiment Mode] FIG. 1 is a view explaining a first embodiment of the present invention. In FIG. 1, a parallel beam which is emitted from a laser light source 1 and enters an AOM2 is modulated in the AOM2 and is emitted as a plurality of diffraction beams such as zero order light, ± first order light. A plurality of diffraction beams emitted from the AOM2 each have a separation angle which depends on a wavelength of an entered beam and carrier frequency of supersonic vibration which is input to AOM. The separation angles of these plural diffraction beams are small. However, when an optical element 31, which has negative power, is provided immediately behind it, a separation angle of a diffraction beam emitted from the optical element 31 can be expanded within a short optical distance by the refraction effect of the optical element 31. The optical element 31 is arranged so that an optical axis of the optical element 31

conforms to an optical axis of a desired modulated beam 5, which is used thereafter; thus, the desired modulated beam 5 passes the lens center, thereby the beam axis travels straight without being refracted. However, the desired modulated beam 5 which is entered as a parallel beam is emitted as a divergent beam. Beams except a desired beam, that is, unnecessary diffraction beams 6 are separated enough from the desired modulated beam 5 in the rear of the optical element 31; therefore, only the unnecessary diffraction beams 6 can be easily blocked by a light shielding member 4 having an opening 4a with appropriate size. Here, preferably, the appropriate size of the opening 4a is slightly larger than the diameter of the desired modulated beam for the above reason. Note that the opening 4a has a size such that an unnecessary diffraction beam is not entered. Power of the optical element 31, distance from the optical element 31 to the light shielding member 4, and the size of the opening 4a are determined so that only the desired modulated beam can be obtained even when there is unavoidable unevenness in precision of components or the like. Here, as the optical element, either a single lens or a compound lens of plural lenses may be used as long as the lens satisfies a purpose thereof. The point is that a lens which can be optically used as one lens can be used. The same applies to the following description.

[0019] FIG. 2 is a view explaining a second embodiment of the present invention. FIG. 2 differs from FIG. 1 in that an optical element immediately behind an AOM is an optical element 32 which has positive power. In FIG. 2, a beam axis of an unnecessary diffraction beam forms a separation angle with a desired modulated beam and seems to be divergent, but each beam is a parallel beam. Therefore, each beam refracted by an optical element focuses at the position that does not accord each other in a focal plane of an optical element. However, a beam axis of each beam converges in the slightly behind the focus position of an optical element and then diverges. A separation angle between each beam before entering the optical element 32 is small. However, a separation angle of a diffraction beam can be extended within a short optical distance by increasing lens power of the optical element 32. A beam axis of the desired modulated beam 5 travels straight without receiving refraction effect by conforming an optical axis of the optical element 32 to a beam axis of the desired modulated beam 5 which is used

in practice. It is to be noted that the desired modulated beam 5 which is entered the optical element 32 as a parallel beam travels as a divergent beam after passing through a focus position of the optical element 32. Unnecessary diffraction beams 6 also focus on a focal plane of the optical element 32 as described above; however, the beam axis crosses a beam axis of the desired modulated beam in the rear of the focus position. Only the desired modulated beam can be taken out by choosing a position of a light shielding member 4 as in embodiment 1, since beam axes of the unnecessary diffraction beams 6 are separated from a beam axis of the desired modulated beam 5 distally at the rear of an intersection point of the both beam axes. When the light shielding member 4 is disposed near the intersection point of the both beam axes, there is a possibility that distance between the both beam axes becomes rather smaller than the distance between both beam axes when the beams is entered into an optical element 3. In order to prevent this problem, it is necessary that the position of the light shielding member 4 be distant from the intersection point by at least the same distance as the distance from the optical element 32 to the intersection point, preferably more than that.

[0020] FIG. 3 is a view explaining a third embodiment mode of the present invention. FIG. 3 differs from FIG. 2 in that an optical element 7 having positive power is disposed behind a light shielding member 4 and forms a beam converter of an afocal system in combination with an optical element 32. In other words, the optical element 7 and the optical element 32 are disposed concentrically so that a focus position of the optical element 7 corresponds with a focus position of the optical element 32. In FIG. 3, the desired modulated beam 5 which is a parallel beam and is entered into the optical element 32 is once converged at the focus position by the optical element 32, and travels as a divergent light, and enters the optical element 7 after passing through an opening 4a of a light shielding member 4 disposed immediately in front of the optical element 7 which is the latter group of the beam converter. As described above, when the desired modulated beam 5 passes through the optical element 7, the desired modulated beam 5 becomes a parallel beam again and travels on an optical axis since the optical element 7 and the optical element 32 are confocal. It is to be noted that, in the drawing, the light shielding member 4 is disposed in front of a position that the beam is entered into the

optical element 7; however, a light shielding member 4' may be disposed immediately behind a position of a beam emitted from the optical element 7 instead of the light shielding member 4 as shown by the dotted line in the drawing, when the only effect of blocking light of unnecessary diffraction beams are considered. The same applies to all the following embodiments. Generally, it is common that unnecessary beams are blocked as soon as possible to prevent unnecessary scattered light in an optical element beforehand. Although not shown, the effect similar to an embodiment of FIG. 3 can be obtained by disposing the optical element 7 having positive power immediately behind the light shielding member 4 in the optical system of FIG. 1 and converting the divergent beam from the optical element 31 into a parallel beam. This structure is advantageous in that light path length can be made shorter than the structure of FIG. 3.

[0021] FIG. 4 is a view of a reference showing that the present invention can be applied to a commonly used modulation method. In FIG. 4, a parallel beam emitted from a laser light source 1 focuses at a modulation position of an AOM2 using an optical element 8 having positive power. This structure is often used since modulation speed can be made faster in this manner. A beam modulated by the AOM2 becomes a plurality of divergent diffraction beams, and is emitted from the AOM2. These beams are changed back into a parallel beam by an optical element 9 having positive power. In other words, the optical element 8 and the optical element 9 also form an afocal system. As to the beams that pass through the optical element 9, only a desired modulated beam 5 can be taken out as a parallel beam using a beam converter including a light shielding member 4 inside in the same manner as the third embodiment. Note that a beam that is modulated in the AOM2 has a divergence angle. If this angle is larger than a separation angle, beams overlap partially and cannot be separated by the light shielding member 4. Since a separation angle of the AOM2 is originally not so large, the distance between the optical element 8 and the AOM2 should be large enough in order to make a separation angle of the beam smaller than that, which is disadvantageous in miniaturization of a device.

[0022] FIG. 5 is a partially enlarged view explaining more preferable conditions for the third embodiment. A beam converter is classified into a beam expander and a

beam condenser depending on the focus distance of the former group and the latter group. In the present invention, both can be adopted in principle; however, the structure of a beam expander is suitable in view of increasing degree of separation. In FIG. 5, each focus distance of an optical element 3 and an optical element 7 of an afocal system lens group which forms a beam converter is assumed to be f1 and f2, respectively. Here, f1 < f2, that is, the focus distance of an optical element of the latter group is made larger than that of an optical element of the former group. Thus, distance between a beam axis of a desired modulated beam and beam axes of unnecessary diffraction beams can be increased by only the ratio of f2/f1 from the distance between beam axes of both beams before being entered into an optical element of the former group at a position of a light shielding member 4 which is disposed almost in contact with the latter group. However, this structure is a beam expander, in which a beam diameter of an output beam is larger than the beam diameter of an incident beam by the same ratio as the above. As described above, it is not preferable to increase beam diameter too much. Therefore, f1 and f2 are determined at a good balance with other elements.

[0023] FIG. 6 is a view showing a fourth embodiment of the present invention. In the drawing, 1-1 and 1-2 represent light sources of laser having different wavelengths, respectively. The wavelengths of lights emitted from them are called λ1 and λ2, respectively. Parallel beams emitted from each of the light sources are modulated by corresponding AOMs 2-1 and 202, respectively, and each of the AOMs emits a plurality of diffraction beams. The plurality of diffraction beams having a wavelength of λ1 emitted from the AOM 2-1 are deflected by a total reflection mirror 10 which is a first deflector. The plurality of diffraction beams having a wavelength of λ2 emitted from the AOM 2-2 are deflected by a dichroic mirror which is a second deflector which transmits the wavelength of λ1 and totally reflects the wavelength λ2. At this time, the total reflection mirror 10 and a dichroic reflection mirror 11 are arranged so that a beam axis of a desired modulated beam 5-1 among the plurality of diffraction beams emitted from the AOM 2-1 corresponds with a beam axis of a desired modulated beam 5-2 among the plurality of diffraction beams emitted from the AOM 2-2 on the same

straight line. Therefore, the plurality of desired modulated beams having different wavelengths seem to be one beam, that is, a synthesized beam 52. Unnecessary diffraction beams 6 deflected by both mirrors 10, 11 pass through a light path different from that of the synthesized beam 52.

[0024] Generally, it is assumed that a laser beam emitted from the laser light source 1 has good parallelism, but it can be slightly divergent after passing through several optical systems. In that case, as shown by two-dot chain line in the figure, a collimating lens 92 having weak positive power may be inserted anterior to the afocal lens system, if necessary. The synthesized beam 52 and the unnecessary diffraction beams 6 are passed through an afocal system similar to embodiment mode 3, and thus, only the synthesized beam 52 can be taken out from an optical element 73 by using a light shielding member 4. By the way, the synthesized beam 52 includes components having different wavelength, λ1 and λ2. Therefore, when a lens system having chromatic aberration is used as the optical element 32 and the optical element 7 as shown in FIG. 3, as for the synthesized beams emitted from the optical element 7, both wavelengths cannot be parallel beams due to difference of refractive indices depending on wavelengths. Thereupon, all optical elements in this case are composed of an achromatizing lens system, that is to say, an achromatic lens system. Therefore, the synthesized beam 52 which enters an optical element 33 and is emitted from the optical element 73 becomes parallel beams regardless of the difference of wavelengths. Although the case of two colors has been described in order to understand easily, it is common to use three primary colors generally in an application such as a display, and it is clear that the present embodiment can be applied in the case of three colors. It is to be noted that, in that case, when a third wavelength is λ3, a dichroic mirror or a bandpass filter which transmits the wavelengths of λ1 and λ2 and reflects the wavelength λ3 totally is used as a third deflector. Other structures are shown in the figure. Although the case of two colors is described in the following figures, structures for three colors are assumed.

[0025] FIG. 7 is a view explaining an example of controlling especially unnecessary diffraction beams so as to be processed easily in the structure of FIG. 6. A diffraction

angle of a beam diffracted by an AOM varies depending on the wavelength of an incident beam. Ultrasonic vibration applied to the AOM is a combination of a carrier and a modulated wave for a signal. The modulated wave is amplitude modulation and appears as intensity variation of a modulated beam. Difference of carrier frequency appears in variation of spacing in grating fringe generated in the AOM. As a result, it appears as difference of separation angles of diffraction beams. In FIG. 6, when the beams having different wavelengths are modulated by the AOMs 2-1 and 2-2 with the use of carriers having the same frequency, as shown in the figure, since the light paths of the unnecessary diffraction beams have different separation angles depending on the wavelengths, the beams pass through different light paths respectively after passing through the dichroic mirror 11. In FIG. 7, frequency of a carrier applied to the AOMs 2-1 and 2-2 are made different from each other in order to control each of the separation angles of the unnecessary diffraction beams so that they become approximately equal, as a result. In accordance with it, the AOM 2-2 and the AOM 2-1 are arranged to be optically symmetric with respect to the dichroic mirror 11 with the total reflection mirror 10 between the AOM 2-2 and the AOM 2-1. As a result, unnecessary diffraction beams 62 having passed through the dichroic mirror 11 follow almost the same light path although they have different wavelengths. Therefore, an opening 4a of a light shielding member 4 can be set to have an most efficient size.

[0026] FIG. 8 is a view showing a fifth embodiment of the present invention, and shows an optical system which can be applied to a scanner or the like. An achromatic collective lens system 12 having positive power is further disposed at the rear of the optical element 73 of the structure in FIG. 7. A synthesized beam 52, which is emitted from the optical element 73, including different wavelengths enters the achromatic collective lens system 12 as a parallel beam. Therefore, the synthesized beam 52 behaves like a beam having one wavelength and beams having any wavelength are focused on the focus position of achromatic collective lens system 12. Accordingly, a color shift dose not occur in using in a display or the like.

[0027] There is no difference depending on the wavelength in focal length of the achromatic collective lens system 12, but a spot diameter in focus varies depending on

the wavelength. The size of the spot diameter is proportional to the wavelength and F-number (an aperture ratio, that is to say, focal length/beam diameter). Since F-number can be reduced by increasing the beam diameter when the wavelength is long, the integrated value of the wavelength and F-number can be made almost equal by controlling the beam diameter. Based on the above-mentioned principle, a convergent spot diameter of the synthesized beam 52 having difference depending on the wavelength can be uniformed. This is effective for use of a laser scan display. As a specific structure, a laser light source having a different emitting beam diameter is adapted or, although not shown, a beam expander or a beam condenser is inserted between the laser light source and deflectors such as a total reflection mirror or a dichroic mirror, therefore, it can be achieved.

[0028] FIG. 9 is a view showing one example of a sixth embodiment of the present invention. In FIG. 9, reference numerals 13, 14 each denote a beam scanning means. In this example, 13 denotes a rotating polygon mirror and 14 represents a galvanometer mirror. An optical system in which beams enter the beam scanning means includes any one of optical systems shown in FIG. 1 to FIG. 8 in at least one part. FIG. 9 shows an example to which the optical system shown in FIG. 8 is applied as is.

[0029] In FIG. 9, although the polygon mirror 13 and the galvanometer mirror 14 are described as the example of the beam scanning means, the reference numeral 13 may represent a galvanometer mirror or the reference numeral 14 may represent a polygon mirror. In the structure of the figure, the polygon mirror 13 scans a modulated beam 5 in a horizontal direction of the paper and galvanometer mirror 14 scans the modulated beam 5 in a vertical direction of the paper. According to the structure in FIG. 9, by using two beam scanning means, a modulated beam 52 scans in two axial directions, that is to say, in two dimensions. However, when a surface to be scanned moves and it is not necessary to scan the beams in two dimensions, the scanning means may be one. Although not shown, if an f-θ lens used in an image forming device or the like is used together and optical systems located anterior and posterior to the scanning means are fitted into the f-θ lens, images without distortion can be displayed on a flat panel display.

[0030] Although a laser marker, a laser trimmer, a laser scan display, or the like can be considered as a beam scanner, it is not necessarily limited to these. According to a device structure means of the present invention, unnecessary beams can be easily blocked within a short optical path length. Since desired modulated beams can be passed through an opening of a light shielding member having an opening greater than the beam diameter, the beams are not diffracted by the edge of the opening. Therefore, when the beams are condensed, a spot without side lobes can be formed. Further, because the unnecessary beams can be prevented from reaching a surface to be processed or a screen, processing quality or image quality can be improved. In addition, because beams having different wavelengths can be condensed at the same focus position, beams having different spot diameters can be processed without changing the position of a processed member. In addition, in a laser scan display in which a screen is irradiated with spots of three colors, displacement of the focus position due to wavelengths causing color shift and difference of spot size do not occur.

[0031]

[Effect of the Invention] According to the invention of Claim 1 or 2, unnecessary diffraction beams of a plurality of diffraction beams emitted from an AOM can be blocked within a short optical path, and a device which dose not include unnecessary components and takes out only desired modulated beams without loss of quantity of light can be downsized. According to the invention of Claim 3 or 4, divergent beams at the point of separating the desired modulated beams from the unnecessary diffraction lights can be returned to parallel beams, and the tolerance permitted on component accuracy or installation accuracy of the device can be largely relaxed.

[0032] According to the invention of Claim 5 or 6, in a laser device in which lasers having different wavelengths are used simultaneously, all the unnecessary diffraction beams are simultaneously blocked by one light shielding member, and the plurality of desired modulated beams having different wavelengths can be handled as if they constitute one beam as a synthesized beam.

[0033] According to the invention of Claim 7, since synthesized beams having different wavelengths can be focused at the same position, color shift dose not occur

when used in a display or the like. According to the invention of Claim 8, when synthesized beams having plural wavelengths are condensed, a condensed spot diameter becomes equal even if they have different wavelengths; therefore, color shift dose not occur when used in a display or the like. According to the invention of Claim 9, since a beam scanner in which an optical system shown in Claims 1 to 8 is used in at least one part can be obtained, the device can be downsized.

[Brief Description of the Drawings]

[FIG. 1] a view explaining a first embodiment of the present invention.

[FIG. 2] a view explaining a second embodiment of the present invention.

[FIG. 3] a view explaining a third embodiment of the present invention.

[FIG. 4] a view of a reference example which shows that the present invention can be applied to a commonly used modulation method.

[FIG. 5] a partially enlarged view explaining more preferable conditions for the third embodiment.

[FIG. 6] a view explaining a fourth embodiment of the present invention.

[FIG. 7] a view explaining an example of controlling especially unnecessary diffraction beams so as to be processed easily in the structure of FIG. 6

[FIG. 8] a view showing a fifth embodiment of the present invention.

[FIG. 9] a view showing one example of the sixth embodiment of the present invention.

[FIG. 10] a reference view showing one example of the related art which increases a distance between a plurality of diffraction beams.

[Explanation of Reference]

1	laser light source
2	AOM
31, 32, 33	optical element
4	light shielding member
5	desired modulated beam
52	synthesized beam
6	unnecessary diffraction beams
7	optical element

10	total reflection mirror
11	dichroic mirror
12	achromatic collective lens system
13, 14	beam scanning means